

(Two shafts, one of pure gold, the other of emerald, which shone remarkably at night.)

Of a list of seven extra-solstitial temples which are named, five are more particularly noticed, viz. :—

A temple at Mycenæ and one near Thebes, which are built nearly north and south, but which probably, as was the case at Bassæ, had eastern doorways. The star, α Arietis, which suits the first, seems to point out the dedication of this temple to Jupiter. The other is very remarkable, and connects the Bœotian Thebes with the great Egyptian city; the star was γ Draconis. Thebes was called the City of the Dragon, and tradition records that Cadmus introduced both Phœnician and Egyptian worship. Three of the temples lay more nearly at an angle bisecting the cardinal points; these are Diana Propylæa at Eleusis, a small temple (not yet named) lately discovered at Athens, and the Temple of Venus at Ancona, recovered by means of the walls of a church built upon its traditional site. In these temples the star observed at the first seems to have been Capella, the time of the year when it shone axially at midnight agreeing with that of the celebration of the Little Mysteries, and in the other two the star was Arcturus.

- II. "On the Coloration of the Skins of Fishes, especially of Pleuronectidæ." By J. T. CUNNINGHAM, M.A. Oxon., Naturalist on the Staff of the Marine Biological Association, and CHARLES A. MACMUNN, M.A., M.D. Communicated by Professor E. RAY LANKESTER, F.R.S. Received March 6, 1893.

(Abstract.)

In normal specimens of the majority of the Flat Fishes, *i.e.*, of the family Pleuronectidæ, the upper side is pigmented, the lower side opaque white, the colours and markings being characteristic of the species. In symmetrical Fishes which swim vertically the dorsal surface is pigmented, the ventral almost or entirely destitute of pigment. Where the pigment is absent or in small quantity the characteristic silvery brilliancy and iridescence of Fishes' skins is exhibited. It has long been known that the pigment in the skins of Fishes and Amphibia is contained in chromatophores provided with contractile radiating processes, and that the iridescence and brilliant reflection of light is due to special anatomical elements of fixed form, all these elements being placed in the category of connective tissue cells. But exact and detailed descriptions of these coloration elements in Fishes are not available. The most complete account of them is that given by G. Pouchet in his memoir on the "Changement de Coloration."

tion sous l'Influence des Nerfs" ('Journ. Anat. et Phys.,' 1876). He there gives the separate reflecting cells the convenient name "iridocytes," and refers to the silvery layer of the skin under the name "argenteum." The anatomical analysis of the structural coloration elements having thus not previously been adequately carried out, we have described these elements as they are found in Pleuronectidæ and various other Fishes. In the former family there are two kinds of chromatophores, the black and the coloured, the latter usually of some shade of yellow or orange. The coloured elements in the skin on the upper side are chiefly developed in the more superficial layer immediately beneath the epidermis and for the most part outside the scales, and on the inner side of the skin in the subcutaneous tissue, the rest of the skin being almost destitute of these elements. In the superficial layer the iridocytes are somewhat polygonal plates of irregular shape, distributed uniformly, and separated by small interspaces. The chromatophores are much larger, and farther apart, and are superficial to the iridocytes, although sections show that their processes often pass down between adjacent iridocytes. The coloured chromatophores have less definite outlines than the black, and as a rule radiating processes are but indistinctly indicated in them. The external part of the coloured chromatophore consists of diffused yellow pigment, while in the centre the concentration of the pigment produces a deeper colour, varying from orange to red, as in the Plaice and Flounder. On the upper side of the Fish the subcutaneous coloration elements are quite similar, but not so uniformly distributed; the iridocytes are larger, and the chromatophores not so symmetrical in shape.

The lower side of the normal Flounder is uniformly opaque white, like chalk. Here in the more superficial part of the skin there is a uniform layer of iridocytes like those of the upper side, opaque and reflecting, but not very silvery or iridescent. Chromatophores are entirely absent. In the subcutaneous layer there is a continuous deposit of reflecting tissue, to which the whiteness of the skin is due, the superficial iridocytes not being sufficiently thick to make the skin so opaque. We have shown by comparing the adults of different species, and stages of growth of the same species (Flounder), that the subcutaneous deposit is merely a further development of a layer of separate iridocytes which enlarge until they become continuous. In some cases, *e.g.*, *Arnoglossus*, the subcutaneous layer of the lower side remains permanently as a layer of separate plates or iridocytes. The continuous deposit in all respects corresponds to the subcutaneous tissue to which is due the silvery glitter of the Mackerel or Herring, and we have called it the argenteum.

We have shown by descriptions of the coloration elements in a number of species of symmetrical Fishes such as Mackerel, Whiting,

Gurnard, *Cottus*, Pipe-fishes, &c., that the general distribution of the elements is constant in all, the differences being in minute details. Thus, there is always an argenteum consisting of reflecting tissue composed of needles or granules in a layer of greater or less thickness. And in the superficial region of the skin there is a layer of chromatophores associated with a thinner deposit of reflecting tissue corresponding to the iridocytes of the Pleuronectid. Thus, in the Herring the superficial reflecting tissue is in the form of a layer of slender rods or prisms lying side by side and adhering to the inner surface of each scale, forming a coating to the latter when it is removed, and endowing it with its beautiful iridescence. The scales themselves are never silvery or iridescent. In the Herring the argenteum consists of similar rods in close apposition, forming laminae. On the dorsal surface of the body, where the argenteum becomes thinner, chromatophores are found on its surface and penetrating it with their processes; on the ventral surface these are absent, and the argenteum is very thick.

The ultimate histological relations of the coloration elements we have not completely elucidated, but have merely described the relations as seen in sections, pointing out the difficulty of regarding the iridocytes of the Pleuronectids as cells, considering their homology with the reflecting tissue in other forms, such as the Herring, and the fact of the argenteum, a continuous deposit whose cellular nature is very improbable, being developed from iridocytes.

In chemical and physical properties the substances contained in the coloration elements are as distinct as the elements are in appearance and form. The black chromatophores owe their colour to a melanin which is granular in its natural condition, is a nitrogenous body, and is very refractory towards reagents. The pigment of the coloured chromatophores is always a lipochrome, and the absorption bands of the various lipochromes obtained from the Fishes examined do not differ to any great degree. The reflecting tissue was found always to consist of guanin in the pure state, not, as has often been stated, to a combination of guanin and calcium. The differences in the appearance of the reflecting tissue in the natural state, whether it is silvery, chalk white, or iridescent, depend on the form of its minute elements. It is chalk white when granular, silvery when composed of very fine needles in a thick layer, iridescent when composed of thicker prisms in a thin layer. The opacity and reflecting power is a property of the guanin itself in any form. Besides these substances, large crystals of phosphate of calcium were found in many skins, both of Pleuronectidæ and other Fishes, and from these or from the scales has probably been derived the calcium supposed to be associated with the guanin.

These investigations of the elements and substances of coloration

were undertaken in order to find out what exactly took place when coloration was developed in the lower side of Flounders in certain experiments carried on at the Plymouth Laboratory since the spring of 1890. The first of these experiments was described in the 'Zoologischer Anzeiger,' No. 354, 1891. The method of the experiments is to take young Flounders in process of metamorphosis, or at a later stage, and keep them in a vessel with a glass bottom without gravel or sand, and then to direct light from a window on to the lower sides by means of an inclined mirror placed beneath the vessel and opposite the window. The first experiment was not quite conclusive, although some pigment was found on the lower sides of the fish after an exposure to light of four months. The second experiment was quite conclusive. Four Flounders were taken on September 17, 1890, from a number reared in the aquarium since the preceding May: they were five to six months old, and 5 to 8 cm. in length. They had been living under ordinary conditions, and were in all respects normal, having no colour on the lower sides. They were placed in the vessel above the mirror. On one of these, two faint specks of pigment were observed on April 26, 1891, one died on the following July 1, which showed no pigment, and one on September 26, 1891. The latter was 16.7 cm. long and showed only a little pigment on the posterior part of the operculum. At this time one of the two survivors had developed pigment all over the external regions of the lower side, and the other had a few small spots. The first of these two is still alive (March, 1893), being now three years old, and it is now pigmented over the whole of the lower side except small areas on the head and the base of the tail. A drawing showing its condition in November, 1891, was exhibited at the soirée of the Royal Society in 1892, and is laid before the Society with this paper. The other specimen died on July 4, 1892. It was then 25 cm. long and had a good deal of pigment in scattered spots on the lower side. This specimen had been exposed about one year and ten months. Several other experiments gave similar results. The Flounders which were reared in the aquarium under ordinary conditions showed no such tendency to develop pigment; a few, as in nature, were found to have small patches of pigment on the lower side, but the percentage was extremely small, and the pigment in such cases was constant, not progressive, as in the fish exposed to light.

The occurrence of abnormal coloration in Pleuronectids is fully considered in the memoir; a large number of specimens are described, and it is shown that there is no evidence whatever that these specimens have been exposed to abnormal conditions. We conclude that these abnormalities are congenital and not acquired.

We find that where pigment is developed on the lower side, whether in the experiments or as a congenital abnormality, the argenteum is

much diminished, as it normally is on the upper side, and it is suggested that possibly there is an inverse physiological relation between the formation of guanin and the formation of pigment.

We conclude that exposure to light does actually cause the development of pigment in the form of normal chromatophores on the lower side of the Flounder, and also causes the absorption of the argenteum to a great extent. We infer, in spite of the occurrence of congenital abnormalities, that the exclusion of the light from the lower sides of Flat Fishes is the cause of the absence of pigment from that side in normal specimens. We think that the fact that the metamorphosis of the Flounder takes place at first normally, in spite of the light coming from below and being shut off from above, is, in respect of the pigmentation, in favour of the inheritance of acquired characters. When the exposure is continued long enough, the change that has taken place in consequence of heredity is reversed, and pigment appears.

We have discussed briefly the question of the physiological process of the formation of the pigment, but we have at present no decisive result to offer in this part of the subject, and need not include it in this abstract.

We consider that these investigations afford support to the view that the incidence of light is the reason why the upper and dorsal surface of animals is more strongly pigmented than the lower or ventral throughout the animal kingdom, and that the absence of light is the cause of the disappearance of pigment in many cave-inhabiting and subterranean animals.

III. "The Electric Organ of the Skate: Note on an Electric Centre in the Spinal Cord." By J. C. EWART, M.D., Regius Professor of Natural History, University of Edinburgh. Communicated by Professor Sir W. TURNER, F.R.S. Received March 15, 1893.

Having considered the development and structure of the electric organ of the Skate, it appeared to me desirable, by way of making my work more complete, to reinvestigate the nervous apparatus of the organ, and more especially to ascertain whether, as in *Torpedo* and *Gymnotus*, there is an electric centre. In *Torpedo* the electric organs are developed from a limited number of myotomes, and innervated by afferent fibres, belonging to a limited number of cranial nerves, which proceed from two large collections of cells—the electric lobes—situated in the region of the medulla. In *Gymnotus* the nerves for the electric organs proceed from two well-marked cellular tracts